

Slide 3 Reference: Bloomberg New Energy Finance, New Energy Outlook 2018.



As PV and onshore wind emerge as the cheapest sources of bulk generation, flexibility becomes a top priority for power grids across the world.

In the meantime, the wide deployment of EVs drives the cost of batteries down.

Cheap batteries mean that wind and solar will increasingly be able to run when the wind isn't blowing and the sun isn't shining.

We expect 1,291GW of new battery capacity added to 2050, some 40% of which will be placed behind-the-meter.

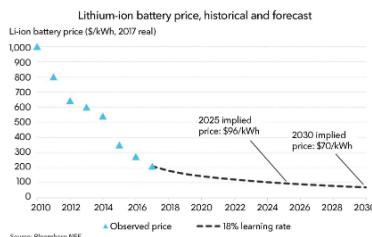
1,291GW Battery capacity added globally between today and 2050
\$70/kWh Price of a battery pack for stationary applications by 2030
40% Share of behind-the-meter batteries globally in 2050 by MW

Source: Bloomberg NEF

Global EV deployment drives down the cost of batteries

Battery prices are already down 79% in 2010, and we expect the ongoing build-out of battery manufacturing for electric vehicles to continue to drive down their prices for stationary applications, so that they reach \$70/kWh by 2030, 67% down from today.

This has profound implications for power grids across the world that are seeing the share of variable renewable penetration grow, making the need for flexibility a top priority.



Source: Bloomberg NEF

Cost competitive batteries mean that variable renewables will increasingly be able to run when the wind isn't blowing and the sun isn't shining

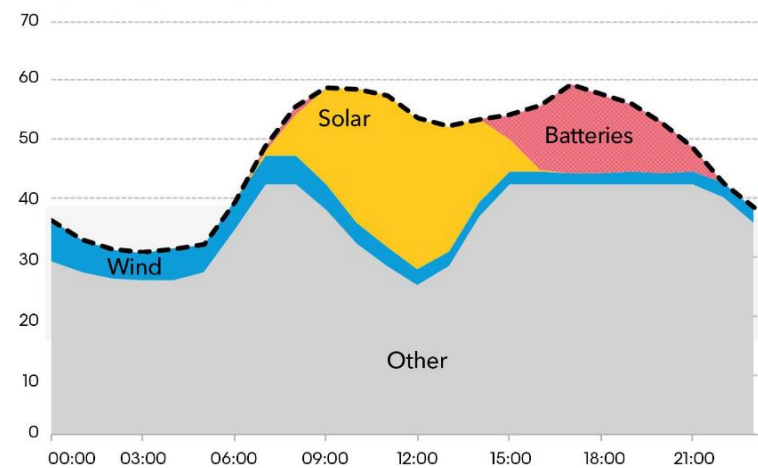
At present, flexibility is provided mainly by a combination of dedicated peaking plants, pumped hydro storage, interconnectors linking neighboring grid systems, and large-scale coal and gas plants that are capable of ramping up and down to meet changes in demand.

By 2030, the configuration of many systems is characterized by PV that meets daytime demand, and batteries that absorb excess generation and discharge at high value, low renewables times, particularly in the evening.

Renewables plus batteries operating together as virtual dispatchable units allow deeper renewables penetration and eat into the remaining market for coal, gas and nuclear.

Cheap batteries can make solar and wind dispatchable

Intraday electricity generation (GW)



Source: Bloomberg NEF

by almost a factor of four by 2050, as a cheaper more nimble alternative to large-scale

CCGT (combined-cycle gas turbine) and coal-fired power plants running at low capacity factors.

Asia Pacific attracts 41% of the investment in batteries to 2050, with \$223 billion equally split between utility-scale and behind-the-meter storage.

Europe follows with \$168 billion, 77% of which goes to utility-scale batteries.

Cheap renewables and the explosion of battery capacity are bad news for most thermal generators, but not all

As thermal plants retire and variable renewables increase the variability on the supply side, new flexible capacity will be needed and there are limits to what renewables and batteries can do together.

Peaking gas emerges as a critical technology, to back up renewables during the extremes when wind and solar are at a minimum (sometimes this can be up to weeks at a time).

We expect peaker gas (i.e., open cycle gas turbines and gas reciprocating engines), to grow